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THE AGE DYNAMICS OF BIOCHEMICAL BLOOD INDICES IN BROILER CHICKEN (*Gallus gallus* L.)

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Abstract

Biochemical blood indices are important characteristics of physiological and health status of agricultural animals and poultry. In the past decades, the advanced measuring methodology and equipment including the development of automatic biochemical analyzers with standardized reagent kits have led to the significantly faster procedures and higher accuracy of analysis. The reference values of the biochemical indices determined by classic methods should therefore be redefined. In this study we report for the first time the revised reference values of biochemical blood indices including circulatory activity of blood digestive enzymes in growing broiler chicks (*Gallus gallus* L.) during early ontogenesis (1 to 35 days of age). In the study, the hybrid chicks of an experimental broiler cross Smena 8 (line B59) were compared to their parental lines (Cornish line B5 and Plymouth Rock line B9) selected at the Smena Center for Genetic Selection (60 birds per genotype).The hybrids were fed ad libitum; parental lines were restricted in feed since day 15 of age. Mortality and live bodyweight were determined at 1, 7, 14, 21, 28, and 35 days of age. Two replicates of 10 birds per genotype were randomly taken for biochemical blood analyses. Blood was sampled from the jugular vein of decapitated chicks. Biochemical blood indices were measured by a flow semi-automatic biochemical analyzer Sinnowa BS3000P (Sinnowa Medical Science & Technology Co., Ltd., China) using reagent kits DIACON-VET (Russia). At 1 day of age in all studied genotypes concentrations of total protein, triglycerides, and calcium in blood serum were lower while concentrations of total phosphorus and total cholesterol were higher as compared to all subsequent ages. The most substantial increase in biochemical blood indices occurred during the first 7 days of age. This was due, among other factors, to the intensive growth of the body and the functional formation of the digestive system for this age period. The total protein concentration in blood serum increased with age in all genotypes because of proceeded body growth and the enhanced ability of protein synthesis. Concentration of total cholesterol tended to decrease with age, especially after 21 days of age. Concentration of triglycerides in serum increased to 14 days of age by 41.6-57.1 % as compared to the previous ages. There were no significant differences between the genotypes in total blood protein until 35 days of age. The hybrid chicks and their parental lines differed in the blood concentration of calcium, total phosphorus, and total cholesterol at 14 and 28 days of age, and triglycerides at 7 days of age. The blood digestive enzyme activities per live bodyweight decreased from day 1 to day 35 of age, most notably for trypsin (501-fold in hybrids, 453-fold in the Cornish line, and 442-fold in the Plymouth Rock line). Blood amylase activity decreased 100-, 52-, 50-fold, and lipase activity decreased 31-fold, 33-fold, and 35-fold, respectively.

Keywords: broiler chicken, total protein in blood serum, lipid exchange, calcium and phosphorus in serum, digestive enzymes in serum

Transportation and regulatory function of blood ensures multiway interaction between the digestive system and metabolism. It manifests itself not only in fine coordination of digestion and metabolism attributable to neural and hormonal regulation, but also to existence of specific functions of gastro-intestinal tract that facilitate chemical processes in tissues. Our experimental data prove the scientific hypothesis [1, 2] about the cycle of digestive enzymes and their existence in blood serum [3-5]. Our prior papers demonstrated the age-related dynamics of pancreatic enzymes in the pancreatic tissue and blood serum of broiler chicks [6].

Blood composition in mammals and birds is stable, since stability of inner environment of the body alone may ensure smooth and precise operation of its systems. Biochemical blood indices are important characteristics of physiological and health status of agricultural animals and poultry. Biochemical indices of chicken blood are known to change with age [7, 8].

Over the past few decades, scientific laboratories have considerably upgraded their equipment. Classical methods made way for semi- and fully-automatic biochemical analyzers with commercial reagent kits, which have lead to much faster and higher accuracy of the studies. Consequently, reference values of the studied indices needed to be redefined. Professional literature offers expansive albeit rather contradictory data on biochemical properties of blood in broiler chicks [9-11], including application of various additives [12-14] and correlation with the age [15]. However, comparative data obtained from reference broiler lines and hybrids are virtually non-existent in freely available publications. Details concerning the changes in biochemical blood indices and digestive enzymes will help trace the evolving metabolic processes in broilers of diverse lines and hybrids during their postembryonic life. This is particularly important in light of new cross lines breeding, as it helps define periods of the effective growth and make sure that the bird is getting adequate diet so as to increase conversion of feed stock into marketable product.

This study reports for the first time reference values of biochemical blood indices, including circulatory activity of blood digestive enzymes in experimental broiler cross and their parental lines during the ontogenesis. Activity of blood digestive enzymes against the live body weight has been found to go down between day 1 and day 35 of life, with biggest changes established for trypsin (501-fold in hybrids, 453-fold in chicks of parental line and 442-fold in chicks of maternal line). Activity of amylase decreased 100, 52 and 50-fold respectively, and lipase decreased 31, 33 and 35-fold.

This paper aimed to study biochemical blood indices in broilers (*Gallus gallus* L.) cross Smena 8 in post-embryogenesis and to compare the same with the birds of reference lines.

Techniques. Studies were carried out in 2017 on reference lines (Cornish Line B5 and Plymouth Rock Line B9) and their hybrids (cross Smena 8 B59) bred at the Smena Center for Genetic Breeding. During the trial period, chicks were kept at the animal facility of the All-Russia Research and Technological Institute of Poultry Farming (60 chicks in each group) in conditions of feeding and upkeep recommended for the relevant cross and parental lines. Ten chicks were taken out of each group for testing, and the tests were run in two replicates. The hybrids were fed *ad libitum*; parental lines were restricted in feed since day 15 of age. Mortality and live bodyweight were determined at day 1, day 7, day 14, day 21, day 28, and day 35 of age.

Blood was sampled from the jugular vein of decapitated chicks. Freshly made sodium citrate solution was added to the test tubes, blood samples were given a centrifuge ride at 5000 rev/min for 5 minutes at a time; the resulting serum was then studied on the flow semi-automatic analyzer Sinnowa BS3000P (SINNOWA Medical Science & Technology Co., Ltd, China) using biochemical reagent kits (DIACON-VET, Russia) to measure total protein, total cholesterol, triglycerides, calcium and phosphorus.

Blood serum was tested for amylase and lipase activity on Chem well 2900 (T) (Awareness Technology, USA) using the appropriate reagent kits (Human GmbH, Germany). During the measurement of pancreatic amylase and lipase activity, 200 μl of buffered solution (Goods buffer, NaCl, $MgCl_2$, α-Glucosidase, monoclonal antibodies against salivary amylase, sodium azide, pH 7.15 for amylase, and Goods buffer, aurodesoxycholate, Desoxycholate, Calcium ions, colipase sodium azide, pH 8.0 for lipase) were mixed with 4.0 μl of blood serum and incubated at 37 °C for 3 and 5 min, respectively. Thereafter, 50 μl of substrate (Goods buffer, EPS-G7, sodium azide, pH 7.15 for amylase, and Tartrate buffer, lipase substrate, propan-1-ol, pH 4.0 for lipase) were added and incubated for 2 min, whereupon λ = 405 nm and λ = 580 nm filters were used respectively to measure absorbance (A) within 1, 2 and 3 min (for amylase) and 1 and 2 minutes (for lipase), followed by calculation of mean values for ΔA/min. Trypsin activity was measured by semi-automatic biochemical analyzer Sinnowa BS-3000P (SINNOWA Medical Science & Technology Co., Ltd, China) [15].

Two trials covering each age group involved at least 20 studies by each indicator. Statistical processing of the findings included calculation of the mean value (*M*) and the standard error of mean (±SEM) in Microsoft Excel 2010. Reliability was estimated by the Student's *t*-test. Differences are considered statistically significant at $p < 0.05$.

Results. Broiler lines and crosses are improved and created at the Smena Center for Genetic Breeding using the latest methods and selection techniques and study aids for evaluation and selection of the young and grown birds [16, 17]. Birds selected for trials were kept on the relevant diets (see composition in Table 1 below).

1. Composition (%) and feed quality indices for broiler chicks (*gallus gallus* l.) cross Smena 8 and parental lines in various ages

Ingredient, indicator	Broiler chicks			Parental line chicks
	days 1-14	days 15-21	days 22-41	days 1-49 сут
Corn	22.000	20.566	17.000	10.000
Wheat	27.806	36.292	40.355	49.480
Soy bean meal	20.107	8.526	2.950	–
Sunflower cake	15.000	20.000	25.000	18.580
Wheat bran	–	–	–	17.310
Corn gluten	7.171	5.709	4.064	–
Soy bean oil	4.000	5.000	6.977	–
Kitchen salt	0.216	0.219	0.217	0.250
Monocalcium phosphate	0.864	0.780	0.617	1.040
Limestone	1.536	1.508	1.470	2.500
Lysine	0.300	0.400	0.350	0.350
Premix	1.000	1.000	1.000	1.000
In 100 g of compound feed:				
metabolizable energy, kcal	305.000	311.000	320.000	255.000
crude protein, g	24.840	21.378	19.786	15.590
crude fiber, g	5.029	4.996	5.211	6.730
calcium, g	0.938	0.889	0.809	1.000
phosphorus, total, g	0.773	0.728	0.683	0.800
phosphorus. digestible, g	0.499	0.469	0.429	–

N o t e. Dashes mean that component does not exist in the diet.

Proteins comprise a most important part of blood serum [18]. Approx. 60% of blood proteins are represented by albumin that plays crucial role in maintaining the oncotic blood pressure and performs transport and nutritional functions. The balance is represented by α- and β-globulins and other serum proteins, including enzymes (trypsin, amylase, lipase). Concentration of protein in blood serum of chicks 1 day of age was much smaller than in all other periods of their life (Table 2), which can be explained by low protein biosynthesis function [18].

2. Biochemical blood indices and live bodyweight for broiler chicks (*Gallus gallus* L.) of parental lines and their hybrids broken down by age (n = 20, M±SEM)

Original lines and hybrid	Index					
	live bodyweight, g	total protein, g/l	cholesterol, mmol/l	triglycerides, mmol/l	calcium, mmol/l	phosphorus, mmol/l
			Day 1 of life			
Line 5	44.8±0.25	27.2±0.36	5.3±0.04	2.3±0.05	3.0±0.10	3.5±0.13
Line B9	43.2±0.23	27.6±0.70	5.2±0.06	2.4±0.03	3.1±0.01	3.7±0.25
Hybrid B59	44.7±0.14	28.9±0.68	5.2±0.09	2.4±0.08	3.1±0.01	4.1±0.27
			Day 7 of life			
Line 5	136.1±1.67	38.9±0.92	5.3±0.05	2.1±0.02	4.3±0.11	2.1±0.03
Line B9	121.8±1.36*	41.0±0.84	5.3±0.02	2.2±0.04	4.3±0.05	2.2±0.04
Hybrid B59	136.1±1.55	38.7±0.81	5.2±0.05	2.4±0.03	4.3±0.05	2.4±0.23
			Day 14 of life			
Line 5	278.0±4.91	33.8±1.18	5.2±0.03	3.3±0.07	4.3±0.15	2.6±0.07**
Line B9	252.3±4.32**	33.1±1.27	5.2±0.04	3.3±0.04	5.5±0.12*	2.6±0.11**
Hybrid B59	313.4±7.62	34.1±0.48	5.9±0.10	3.4±0.10	4.6±0.06	2.1±0.09
			Day 21 of life			
Line 5	578.1±13.93**	35.2±0.67	3.7±0.03	3.2±0.04	3.8±0.11	1.8±0.09
Line B9	499.0±11.41**	34.8±1.14	3.8±0.04	3.1±0.04	4.1±0.13	1.8±0.05
Hybrid B59	677.5±19.50	33.7±0.49	3.8±0.02	3.2±0.06	4.0±0.09	1.7±0.12
			Day 28 of life			
Line 5	967.1±24.31**	38.7±1.04	3.8±0.04	3.1±0.02	3.5±0.19**	1.9±0.07*
Line B9	796.0±2.62**	40.6±0.82	3.8±0.04	3.1±0.02	4.5±0.13	1.9±0.05*
Hybrid B59	1146.1±38.43	39.8±1.27	4.2±0.12	3.2±0.06	4.3±0.06	2.4±0.21
			Day 35 of life			
Line 5	1609.2±26.91**	41.4±1.31	4.6±0.12	3.3±0.11	2.8±0.05	2.3±0.04
Line B9	1394.0±30.62**	41.7±0.81	4.4±0.05	2.9±0.02	3.0±0.03	2.2±0.05
Hybrid B59	1996.3±98.31	40.7±2.04	4.5±0.07	3.2±0.18	3.1±0.22	2.3±0.04

*, ** Differences with hybrid birds are statistically significant at $p \le 0.05$ and $p \le 0.001$ respectively.

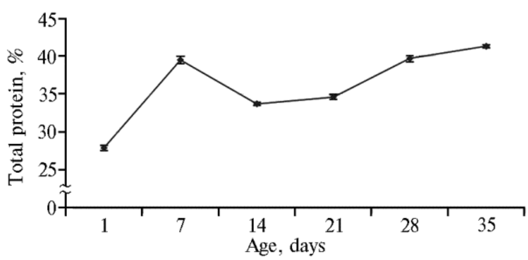

Fig. 1. Total protein content in blood serum of broiler chicks (*Gallus gallus* L.) of cross Smena 8 birds and parental lines depending on age (mean indices by the three groups, n = 30).

By day 7, total blood protein would increase sharply (by 33.9%-48.5%) and reach the peak value. In chicks of parental line B9, concentration of protein in blood serum positively exceeded the same index in hybrids and chicks of parental line B5 by 5.4% ($p < 0.1$). By day 14, protein content would drop to approx. 33.1 g/l in each group and then keep stable for the next week of life. By day 28, it would grow up to 40.6-41.7 g/l ($p < 0.05$) and then stabilize until day 35 (Fig. 1).

Lipid metabolism in birds is an important issue, since lipids serve as energy-intensive substrate: oxidation of 1.0 g of fat generates 2.2-fold more energy than proteins and carbohydrates. Fats mobilize calcium out of the intracellular depot, regulate many biological processes in blood, stimulate digestive function of pancreatic gland and increase the lipase content in pancreatic fluid. Neutral fats occur in the body in the form of storage and protoplasmic fat that includes phospholipids and lipoproteids. Cholesterol is cyclic mono alcohol that occurs in the outer cell membranes [19]. It serves for the synthesis of pregnenolon — precursor of all steroids (aldosterone, cortisol, corticosterone, progesterone, estradiol, testosterone, choleric and other bile acids, a D vitamins). Triglycerides (true fats) are the derivatives of tri-alcohol glycerin and higher fatty acids [19].

Cholesterol and triglycerides content in one-day-old chicks did not differ from adult birds (see Table 2). On day 21, cholesterol content would drop by 30.2% in chicks of parental line and by 27.0% in chicks of maternal line and broiler chicks compared to 1 day of age. This index would remain unchanged until day 35 when the indices would grow by 21.0%, 15.8% and 7.1% respectively against prior period. Triglycerides content in blood would stay virtually unchanged until day 14 of age, after which it would grow by 43.5% in chicks of parental line, 37.5% in chicks of maternal line and 41.7% in broiler chicks. This index would stay until day 35.

Minerals take part in keeping the body properly hydrated and maintaining normal pH balance, distributing fluids in the body, triggering the nerves and muscles, promoting conductivity of nerve impulses in nerve fibers, etc. [20]. They occur in supporting tissues (calcium) and compounds rich in energy (sulfur, phosphorus), affecting the enzyme activity and functions of a live body. Considerable role here belongs to calcium, phosphorus, magnesium and a number of microelements [20]. What makes mineral metabolism in chicks particularly unique is that intake and elimination of minerals are not balanced, which influences productivity indices [20].

About 50% of blood serum calcium is ionized, 45% is tied with albumins and approx. 5% with phosphates and citrates. Calcium content in blood is defined by the balance between the intestinal absorption, distribution between cellular spaces in the body, bone metabolism and renal elimination. These processes are controlled by parathyroid hormone (parathormone), thyrocalcitonin and the active form of vitamin D [21]. All metabolic processes in the body are inextricably intertwined with phosphoric acid transformation. Phosphorus mostly occurs in the form of anion PO_4^{3+}. Its involvement includes the energy supply to the body and participation in metabolic processes [21].

Newly hatched chicks had considerably low calcium content in their blood serum, but within a single week of their postembryonic life it would grow by 38.7% and stay on that level (with slight fluctuations) until day 35. on day 14, one would detect differences in blood serum calcium content in hybrids and line B9 chicks: in the latter, calcium content was considerably higher than in hybrids (by 19.6%, $p < 0.001$) and line B5 chicks (21.8%, $p < 0.01$). By day 28, this index would grow in hybrids compared to line B5 chicks by 18.6%. On day 35, calcium content would drop down to 2.8±0.05 and 3.0±0.03 mmol/l in chicks of parental lines and 3.1±0.22 mmol/l in hybrids.

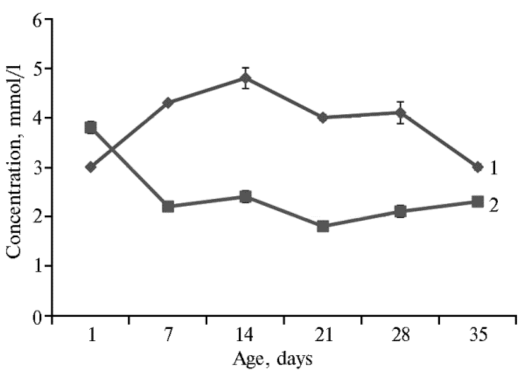

Fig. 2. Calcium (1) **and phosphorus** (2) **content in blood serum of broiler chicks (*Gallus gallus* L.) of cross Smena 8 and birds of parental lines, depending on their age** (mean index for three groups, $n = 30$).

Phosphorus content was high in chicks 1 day of age, but by day 7 it would go down 1.7-fold (Fig. 2). Slight decline was observed until day 21, followed by an upward trend on day 28, which continued up to day 35. Differences in concentration of phosphorus in blood serum were observed in 14 days of age (in chicks of parental lines higher by 23.8% than in hybrids) and 28 days of age (20.8% higher in hybrids than in chicks of parental lines).

In chicks 1 day of age, the calcium/phosphorus ratio was 1:0.8-1:0.7 due to fetal life and the appropriate mineral metabolism. By day 7, the ratio shifted toward the increased calcium, up to 1.9:1, and by day 14 it would grow up to 2.2:1 in hybrids and 2.1:1 in chicks of parental line B9, and would go down to 1.6:1 in chicks of parental line B5. At the age of 28 days, calcium/phosphorus ratio would shift upwards for chicks of line B9 (2.4:1), and at the age of 35 days it would go down in hybrids (1.3:1), chicks of line B9 (1.4:1) and line B5 (1.2:1).

In addition to transportation, blood also performs regulatory function due to availability of hormones, peptides, minerals and enzymes. Digestive enzymes are known to come to the blood stream and perform regulatory function [1, 2, 22]. Therefore, biochemical analysis of blood would be incomplete without data on age-related changes in digestive enzymes in broiler chickens' blood serum. By day 21 of life of the chicks of parental and maternal lines, the amylase activity would go down by 53.8% and 52.1% respectively. By day 35 of life, however, it would grow by 15.5% and 17.2% respectively against the indices for day 1 of life (Table 3). The amylase activity per unit (g) of live bodyweight would go down steadily with age: between day 1 and day 35 — 58-fold in chicks of parental line, and 50-fold in chicks of maternal line. The amylase activity would grow in hybrids between day 1 and day 14 by 93.1%, followed by the abrupt decline in blood serum enzyme activity, by 55.6% compared to chicks on their day 1 of life. Over 35 days of growing, the amylase activity per unit of live bodyweight of broilers would drop 100-fold, i.e. much harder (almost twice) than in the species of parental lines.

Between day 1 and day 7 of life, the lipase activity would grow by 66.7% (parental line, $p < 0.001$), 53.3% (maternal line, $p < 0.001$) and 64.3% (hybrids, $p < 0.001$). By day 28 of life, these indices would drop 2.5-2.3-fold in all three groups, however bouncing back by day 35 of life to the indices recorded for chicks 7 days of age. The lipase activity per unit of the bird's weight between day 1 and day 35 of life would go down in chicks of parental line 33-fold, in maternal line 35-fold, and in hybrids 31-fold.

3. Activity of digestive enzymes in blood serum and their ratio per unit of live bodyweight of broiler chicks of parental lines and hybrids depending on their age (n = 20, M±SEM)

Original lines and hybrid	Amylase activity		Lipase activity		Trypsin activity	
	in blood serum, U/l	relative to bird's weight (g)	in blood serum, U/l	relative to bird's weight (g)	in blood serum, U/l	relative to bird's weight (g)
Day 1 of life						
Line 5	827±132.9	18.45	15±0.8	0.33	203±12.7	4.53
Line B9	929±92.9	21.50	15±0.9	0.35	191±11.2	4.42
Hybrid B59	671±50.5	15.00	14±0.3	0.31	224±12.1	5.01
Day 7 of life						
Line 5	704±66.3	5.17	25±1.7	0.18	29±5.2	0.21
Line B9	926±107.9	7.60	23±1.5	0.19	21±1.9	0.17
Hybrid B59	1001±21.4	7.35	23±1.5	0.17	19±4.3	0.14
Day 14 of life						
Line 5	583±56.6	2.10	20±3.7	0.07	30±3.7	0.11
Line B9	832±136.3	3.29	21±2.3	0.08	30±1.4	0.12
Hybrid B59	1296±358.3	4.13	16±1.7	0.05	29±3.5	0.09
Day 21 of life						
Line 5	382±39.0	0.66	15±0.5	0.02	29±3.6	0.05
Line B9	445±103.7	0.89	14±1.3	0.03	23±3.2	0.05
Hybrid B59	525±95.0	0.77	18±2.2	0.03	23±2.1	0.03
Day 28 of life						
Line 5	564±124.0	0.58	10±1.4	0.01	18±1.2	0.02
Line B9	642±82.3	0.81	11±0.6	0.01	20±1.4	0.02
Hybrid B59	516±86.7	0.45	10±1.4	0.01	19±1.4	0.02
Day 35 of life						
Line 5	510±71.3	0.32	22±2.2	0.01	16±1.1	0.01
Line B9	605±86.3	0.43	18±1.1	0.01	12±2.5	0.01
Hybrid B59	298±28.2	0.15	20±2.8	0.01	23±3.6	0.01

High trypsin activity was observed in blood serum of one-day-old chicks, which could be attributed to production of sufficient amounts of substances inhibiting the enzyme activity over the period of embryogenesis. By day 7 of life, trypsin activity dropped in chicks of parental line 7.0-fold; maternal line — 9.1-fold; and in hybrids — 11.8-fold. Consequently, this index would go down steadily both in terms of absolute values and relative to live bodyweight. Over 35 days of trial, relative trypsin activity index per unit of live bodyweight went down in chicks of parental line 453-fold; maternal line — 442-fold; and in hybrids — 501-fold. This may be attributed to inhibition of proteolytic activity of embryo in the egg by the existence of high absorption proteins that are used for building of body tissues [23]. Therefore, relative decrease in activity of digestive enzymes in blood serum with age is indicative of decreasing intensity of metabolic processes in the body and likewise is indicative of regulatory functions of enzymes, especially trypsin.

In our trial, blood serum protein content in one-day-old chicks was much smaller than in any subsequent period of their life. Similar phenomenon is observed in children and is attributed to low protein production on this stage of ontogenesis [18]. Total protein growth index in broilers is observed between day 14 and day 42 [24]. Total protein content in the blood of birds is contingent on such factors as fatty deposits [25] and stress [26]. The identified dynamics of total protein concentration in blood serum of chicks appear to be consistent with age-related trypsin activity modulations [23], changing in the course of formation of digestive function in early ontogenesis oand depending on the quantity and quality of protein in feed [27].

The observed fluctuations in concentration of cholesterol and triglycerides were consistent with age-related fluctuations in activity of lipase in broilers and chicks of parental lines: we have earlier detected the decreasing enzyme activity in pancreatic gland tissue and in blood serum after day 21 of life [23]. One should keep in mind certain ambiguity of academic papers regarding the content of cholesterol and triglycerides in blood serum of the birds. For example, according to S.Y. Gulyushin et al. [28], cholesterol content in the blood of broiler chicks cross Cobb Avian 48 on day 36 of life was 2.8 mmol/l. According to S.A. Yermolina et al. [29], concentration of cholesterol in broiler chicks cross Smena 7 went as high up as 5.8±0.10 mmol/l. According to O.S. Kotlyarova [9], concentration of cholesterol in blood serum of broilers cross ISA Hubbard F15 depends on the age: for chicks on day 12-day 14 of life 2.1-3.8, day 18-day 20 4.5-4.6, day 24-day 26 2.7-4.9, and day 34-day 36 3.2-3.6 mmol/l. A.G. Koshchayev [30] mentions cholesterol index of 0.25 mmol/l. It is common knowledge [31] that intensity of lipid metabolism is affected by controlled feeding of broiler chickens in the early period of ontogenesis.

According to Y.N. Nazarova [9], content of triglycerides in broilers cross Smena 7 would vary with age (in one-day-old chicks 0.69 mmol/l; on day 7 0.77 mmol/l; on day 14 0.66 mmol/l; on day 21 0.68 mmol/l; on day 28 0.59 mmol/l; on day 35 0.61 mmol/l). Based on the obtained data, the author concludes that bile acids inhibit lipids absorption in gastrointestinal tract, thereby causing fat transit through the digestive system, which results in decreasing concentration of lipids in blood serum. According to A.G. Koshchayev [30], triglycerides content in the blood of broiler chicks was 0.02 mmol/l. In cross Hubbard broilers, concentration of triglycerides in blood serum would vary between 0.28 and 0.51 mmol/l [20].

Therefore, our findings in the context of the patterns of protein, lipid and mineral metabolism in broiler chickens in ontogenesis and in comparative aspect (parental lines and their hybrids) expand the concept of biological peculiarities of formation of digestive function in birds. The obtained results help identify critical growth periods of functional genesis and adaptation of all systems of the body. On these stages birds need more favorable feeding and treatment, which will have considerable impact on livability and productivity of the species. Our data further expand the available information on digestive enzymes in blood serum of the birds. It should be noted, studies like this are quite sparse [32] and data on the age-related dynamics of enzyme activity in broiler lines and hybrids are virtually non-existent.

To sum up, total protein, triglycerides and calcium content in blood serum of one-day-old broiler chicks of parental lines Cornish, Plymouth Rock and their hybrids cross Smena 8 is low, while phosphorus and cholesterol content is rather high. The key blood-related indices are likely to peak by day 7 of life due to intensive growth and functional formation of the digestive system. Total protein in hybrids and chick of parental lines keeps growing with age due to the development of body and improvement of protein production function. Lipid metabolism indices go down as the bird grows older especially after day 21. Triglyceride content dynamics are characterized by the reverse tendency: by day 14 the content grows by 41.6%-57.1% compared to prior indices. Until day 35, hybrids and chicks of parental lines do not considerably differ in terms of total protein. However, there are differences in concentrations of calcium (14 and 28 days of age), phosphorus (14 and 28 days of age), cholesterol (14 and 28 days of age) and triglycerides (7 days of age). Indices of activity of digestive enzymes in blood in relation to live bodyweight of broilers go down with age, with most considerable changes occurring to the content of trypsin: 501-fold in hybrids, 453-fold in chicks of parental line, and 442-fold in chicks of maternal line (from day 1 to day 35). Amylase activity in terms of the live bodyweight of the bird goes down 100-fold, 52-fold and 50-fold respectively, and lipase goes down 31-fold, 33-fold and 35-fold.

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